- Application Note -

Testing Phase Shifting Transformers Using DV Power TRT Devices

Introduction

Transformers are used to transform electric power between different voltage levels of the electric grid. They may also be used to control the phase angle between the source and the load side. Such special transformers are called phase shifting transformers (PST), phase angle regulating transformers or simply the phase-shifters. These transformers shift the phase angle between the primary side AC voltage (usually the Sorce) and the secondary side AC voltage (Load).

When power flows through two or more parallel lines between two different systems, their impedances will determine the load sharing between them. Sometimes in practice, the control of loading and power exchange between different segments of the electric network can be improved by introducing a phase angle adjusting device, i.e. a phase shifter. By changing the phase angle between the primary and the secondary side of the PST, the equivalent system impedance is being changed and thus the loading is being improved. By balancing the power flow in the network, grid owners can minimize the electrical losses in their system. Therefore, regular maintenance of a PST as an important asset can help in reducing the losses.

PST basics

A PST typically consists of the two separate transformers: a shunt unit and a series unit. The shunt unit has its windings connected across the phases, so it produces output voltages shifted by 90° with respect to the input (supply) voltage. The shunt output is then applied as the input to the series unit. Since its secondary winding is connected in series to the main circuit, it creates a phase angle shift.

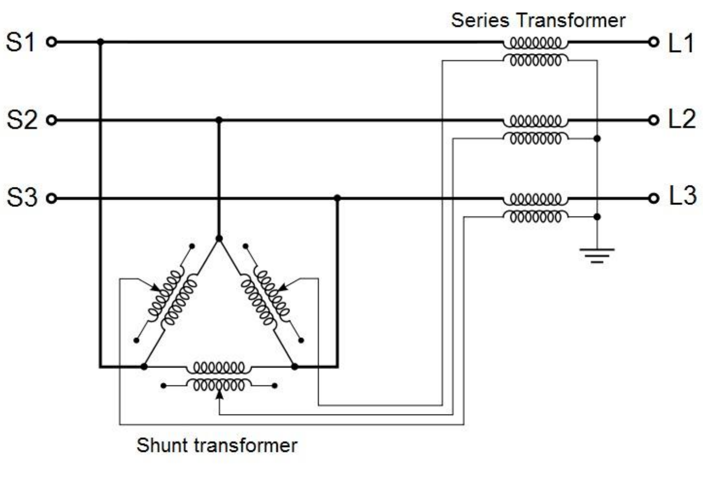

Figure 1. *Basic scheme of a PST*

Testing PST

Testing of a turns ratio and especially a phase angle of a PST is the best way of determining possible faults inside the PST. DV Power True Three-Phase Transformer Turns Ratio Testers (TRT) series of instruments are the ideal tool for these tests. They can generate and output the true three-phase test voltage, and measure the three induced phase voltages at the same time. This enables the TRT to test any transformer, including PST, a rectifier, an arc-furnace and traction transformers.

By applying the true three-phase test voltage to the Source side of a PST, the transformer acts in the same way as if it is connected to the grid. It creates a phase shift between the true three-phase voltage applied to its Source side and the true three-phase voltage induced at its Load side. The TRT measures the three voltages on the source side, as well as the three induced voltages at the load side. The corresponding phase voltages are then compared and phase shift between them is measured. The TRT uses extremely accurate method to measure phase shift between two voltage vectors. The typical phase angle measurement accuracy of TRT devices is ±0.05º, while the measurement resolution is 0.01º. This makes the TRT devices currently the most accurate devices in the market.

The testing procedure is very simple. The TRT needs to be grounded properly, and after that connected to the PST. The example of a connection is illustrated in the figure 2.

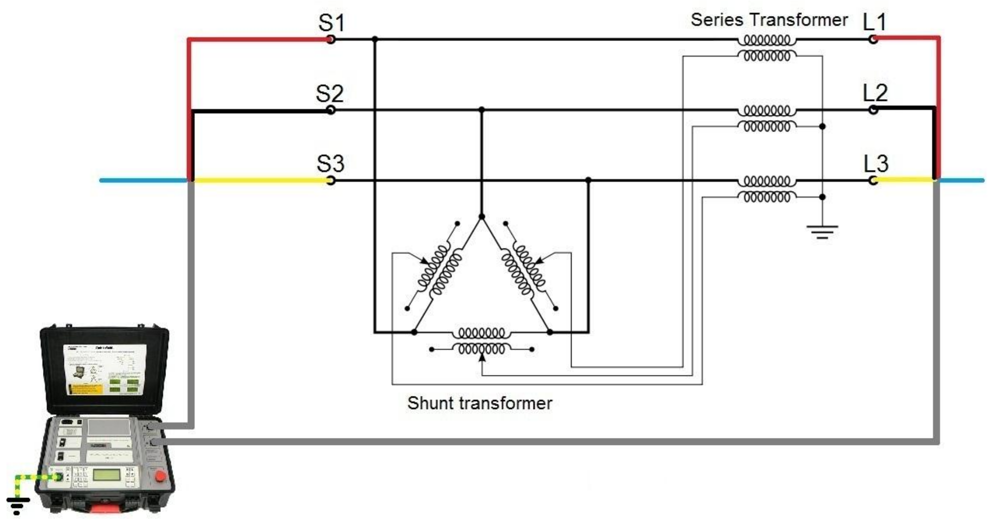

Figure 2. *Example of connecting the TRT to a PST*

After the device is turned on, the true three-phase test needs to be selected in the Configuration menu, as shown in the figure 3.

Figure 3. *Selecting true three-phase test*

The second step is entering the primary (HV) and secondary (LV) name plate voltages, as well as the HV and LV tap positions.

Figure 4. *The screen for entering name plate voltages and tap positions*

The third step is selecting the test voltage. Recommendation is to select the highest possible test voltage.

Figure 5. *Selecting test voltage*

The last step is the "ready" state, where the selected parameters are displayed for a review and confirmation.

Figure 6. *The ready state before starting the test*

After one tap has been tested, the TRT asks if the next tap is to be tested. Choosing “Yes” will lead a user to the second step.

Figure 7. *The test next tap screen*

This procedure is repeated for all tap positions.

The highest test voltage of 250 V AC allows the TRT to test a PST of any size. The TRT63 passed the test requirements on a large 845 MVA, 240 kV, ±47º PST in Canada. Phase angles in all 66 positions were successfully measured. The results of 33 positions are shown in the table below.

Table 1. *Phase angle results obtained with TRT63A on 845 MVA PST*

Tap Position	Nominal phase angle	Measured phase angle		
		Phase A	Phase B	Phase C
33_33	-47	-46.9	-47.1	-47
33_32	-45.7	-45.6	-45.8	-45.7
32_32	-44.4	-44.2	-44.5	-44.4
32_31	-43	-42.9	-43.1	-43
31_31	-41.7	-41.5	-41.8	-41.7
31_30	-40.3	-40.2	-40.4	-40.3
30_30	-38.9	-38.8	-39	-38.9
30_29	-37.5	-37.4	-37.6	-37.6
29_29	-36.1	-36	-36.2	-36.2
29_28	-34.7	-34.6	-34.8	-34.7
28_28	-33.3	-33.2	-33.4	-33.3
28_27	-31.9	-31.8	-31.9	-31.9
27_27	-30.4	-30.3	-30.5	-30.5
27_26	-29	-28.9	-29	-29
26_26	-27.5	-27.4	-27.5	-27.5
26_25	-26	-26	-26.1	-26.1
25_25	-24.5	-24.5	-24.6	-24.6
25_24	-23	-23	-23.1	-23.1
24_24	-21.5	-21.5	-21.6	-21.6
24_23	-20	-20	-20.1	-20.1
23_23	-18.5	-18.5	-18.6	-18.6
23_22	-17	-17	-17	-17
22_22	-15.5	-15.5	-15.5	-15.5
22_21	-13.9	-13.9	-14	-14
21_21	-12.4	-12.4	-12.4	-12.5
21_20	-10.9	-10.9	-10.9	-10.9
20_20	-9.3	-9.33	-9.35	-9.36
20_19	-7.8	-7.77	-7.78	-7.8
19_19	-6.2	-6.22	-6.25	-6.26
19_18	-4.7	-4.68	-4.69	-4.69
18_18	-3.1	-3.12	-3.12	-3.13
18_17b	-1.6	-1.56	-1.57	-1.57
17b_17b	0	0	0	0

Note: Phase A is considered to be associated with S1 and L1 terminals. Phase B is considered to be S2 and L2, while phase C is connected to the S3 and L3 terminals.